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Preliminary Analysis of Growth and Yield Parameters in Rice Cultivars When Exposed to Different Transplanting Dates

Mohammad Taghi Karbalaei Aghamolki[1], Mohd Khanif Yusop[1,*], Hawa Zee Jaafar[2], Sharifh Kharidah[3], Mohamed Hanafi Musa[1], Peiman Zandi[4]

1 Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia;

2 Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia;

3 Department of Food Science, Faculty of food Science Universiti Putra Malaysia, 43400, Serdang, Selangor, Malaysia;

4 Department of Agronomy, Takestan Branch, Islamic Azad University, Takestan, Iran.

*Corresponding author. Tel: +98 (0)9111128366; E-mail: z_rice_b@yahoo.com ; khanif@upm.edu.my

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Review Article

Abstract

The growing seasons usually depends on the seedling transplanting dates. Proper sowing time is good cultural practice to complete growing phase successfully. This research was conducted on the basis of randomized complete block design with split plot arrangement (three replicates) during the 2012 cropping season at Rice Research Institute of Iran, Mazandaran. Three seedling transplanting dates (1st May, 21st May and 10th June) and six rice cultivars (‘Neda’, ‘Hovaze’, ‘Hashemi’, ‘Domsiah’, ‘Tarom’ and ‘Fajr’) were studied. Among the studied cultivars, ‘Neda’, transplanted on 21st May, recorded higher effective tillers, fertile spikelets, bolder grains with greater 1000-grain weight and grain yield. However, panicle exertion, 1000-grain weight and fertile spikelets were equally greater with non-significant differences in 1st and 21st May except for plant height which declined in the early and mid transplanting. The suitability of early and mid transplanting was mainly due to favourable weather temperature during the growing phase. Correlation coefficient analysis showed that a unit increase in effective tillers, total number of spikelets and 1000-grain weight correspondingly increased grain yield by 236.6, 39.4 and 72.1 kg/ha, respectively. Irrespective of cultivars type, the late transplanting of 10th June increased plant height while it decreased important yield components. Observed trends associated with growth and yield features were found to be similar in all the studied cultivars. The study concludes that rice crop may be sown on early and mid transplanting dates (1st or 21st May) for achieving better growth and grain yield.

Keywords: Growth; Rice; Transplanting date; Yield components.

1. Introduction

Nowadays, Rice (*Oryza sativa* L.) is gradually representing as the main food regime among the world countries [1]. In Asia, it is the main staple food of about 3.5 billion people [2]. Its daily demand is increasing and would reach 70 percent more due to increase in population by 2025 [3]. Among the constraints in rice production, the microclimate like time of transplanting has focused attention of many researchers. The transplanting dates have direct effect on length of growing season which may reduce yield by 20 to 50% by 2050 in rainfed area [4]. Among the rice production tools, the proper sowing time is prerequisites that allow the crop to fulfil its life span on a timely manner and successfully in a particular micro climate condition [5]. Accordingly, suitable planting date is known as the major components in efficient agricultural management playing a significant role in production control [6]. The variation in planting date might influence crop yield through affecting plant phonology in vegetative and the reproductive growth stages [7]. The appropriate planting dates ensure satisfactory vegetative growth, grain quality and quantity [8].The transplanting dates are associated with increase in temperatures which is main reason of spikelet sterility at flowering stage. Any type of increase in ambient temperature within the grain filling period improves the rate of metabolic actions and, as a consequence, expedites the grain filling rate [9]. Rice is normally transplanted in between May and July [2]. The effects of transplanting dates vary between regions, which can affect plant initial growth and grain yield [10]. Early transplanting produces more tillers, biomass, taller plants, bolder grains with higher 1000-grain weight and grain yield [11]. On the contrary, in late transplanting most of the panicles become immature and grain yield is reduced in long-duration varieties [12]. The late transplanting limited the growth period which further reduced the leaf surface, panicle length and the mean number of kernels per panicle [2]. Delayed transplanting of rice decreases the amount of productive tillers and spikelets, deters panicle heading [13] and ultimately reduces the weight of the grains, but however, promotes the grain's protein content [14]. Various authors also reported the benefits of optimum planting dates in rice [15,16]. In most of the offered reports, it has been affirmed that sowing in the range of neither too early nor too late gives better yield performance through lengthening the growth period while alleviating the possibility of exposure to heat stress during reproductive growth [17]. The local recommendation of a transplanting date should be considered looking the climate condition and rice cultivars [18]. Accordingly, this research was initiated to assess the best planting date for different rice cultivars to achieve maximum grain yield of rice. Hence, the study was undertaken to identify the best transplanting time among the select rice cultivars under moderate climate.

2. Methods

2.1 Location of the experimental site and climatic condition

This study was conducted in the research field of Rice Research Institute (RRI), Mazandaran, Iran (latitude 31° 20' N, longitude 48° 41' E, altitude 22 m above mean sea level) during the period of 2012 cropping season. This site has a temperate climate with mean annual rainfall varying between 718 to 1274 mm, while the yearly average temperature ranges from 12.5 to 20°C [19].

2.2 Soil status

The experimental soil was clay loam, total nitrogen of 2.2%, phosphorus and potassium content of 160 and 20 mg/kg, respectively, with a pH of 6.9.

2.3 Experimental design and treatments

The study was done as split plot designed according to completely randomized blocks with three replications. The seedling transplanting dates, i.e., 1st May, 21st May and 10th June were set as main plots, and six rice cultivars, i.e., 'Neda', 'Hovaze', 'Hashemi', 'Domsiah', 'Tarom' and 'Fajr' were allotted to subplots. The selection of cultivars and transplanting dates was done according to the conventional crop patterns in the region.

2.4 Agronomic practices

The seedlings were grown at 25 x 25 cm distance (2-3 seedlings per hill) in the main plots. After seedling establishment, the water level was maintained constant (3-4 cm height) in the whole growth period. The N-P-K was applied at 125-60-45 kg/ha. The whole amount of P (ordinary superphosphate) and K (potassium chloride) were applied during the soil puddling. However, N fertilizer was used in three equal doses, i.e., 50% at the time of seedling transplanting, 25% at the active tillering and the rest 25% in the panicle initiation stage.

2.5 Data gathering and measurements

The soil pH was determined through pH meter (Mettler Toledo MP 120), soil texture by the Bouyoucos Hydrometer method [20], total nitrogen (%) by Kjedahl method [21], available phosphorus and potassium (mg/kg) by AB-DTPA method [22]. The flag leaf length and width was measured through measuring tape. The distance from base to the tip of the panicle was considered as plant hight. The plant height was measured using 20 primary tillers selected randomly from each experimental plot and then the recorded data were averaged. The selected plants were then kept for further measuring (number of tillers and panicles per plant). Panicle length and panicle exertion were counted from the lowest point of the panicle (panicle base) to highest point (panicle tip) employing a meter stick. Fertile and unfertile spikelets were counted from 20 randomly selected panicles taken from each plot. Thousand-grain weight was estimated by weighing on digital balance. Each plot was harvested and threshed manually to determine grain yield per square meter and computed on a hectare basis.

2.6 Statistical analysis

Data were exposed to the SAS statistical software [23] for analysis of variance (ANOVA). The treatment means were compared through employing least significant difference(LSD) test at 5% probability level ($p<0.05$).

3. Results and Discussion

The rice crop transplanted on 21st May recorded higher values of important yield components. The transplanting of 21st May recorded higher number of effective tillers (21.80 numbers) and grain yield (6625 kg/ha) in cultivar 'Neda'. However, 1st May transplanting showed non-significant differences between the mean values of 21st May of other yield contributing traits by producing maximum fertile spikelets (124–130) per panicle in 'Hovaze' and 'Fajr', and 1000-grain weight (28.83–29.0 g) in 'Neda'. The increase in yield could be predicted due to less number of sterile spikelets in both 1st and 21st transplanting dates. Regarding morphological characters, only total number of tillers per hill (25.0; 'Neda') and panicle exertion (9.1 cm; 'Domsiah') were greater in 21st May sowing date, indicating that the environmental condition like temperature was most favourable for grain development. Irrespective of the studied cultivars, the morphological traits of plant height and flag leaf length declined in the early (1st May) and mid (21st May) transplanting dates, however, the flag leaf width in all the studied transplanting dates was amongst the highest mean values in the studied cultivar of "Hovaze". The allocation of the highest flag leaf width to 'Hovaze', suggests its specific genetic feature in comparison with other cultivars (Tables 1 and 2). The sooner transplanting of the usual plantation time in a given region, the more time intervals within the following cropping will provides. Inversely, delayed planting will reduce the grain yield as a result of immaturity of most of the panicles [12]. Achieving the proper ranges in plant height, 1000-grain weight, grain yield and maximum tillering is highly dependent on the early sowing date [11]. Bashir *et al*. [2] demonstrated that number of kernels per panicle was better with early sowing, but, however, late sowing restricted the growth period, decreased the length of panicle, leaf area, and number of kernels per panicle. In their study, Soleymani and Shahrajabian [24] came to a result that sowing on 25th May is an adequate time for attaining the greatest number of grains, 1000-grain weight, and grain yield. It can be mentioned that the crop grown on optimum dates, is usually taken a more suitable number of days from the seeding to maturity time, so as to be capable of exploiting a more efficient sink development or its formation, more potent and wide-spreading root system, greater carbohydrate and sink size, and durable leaf area index; indicating better translocation of assimilates from vegetative parts (second sources) into the spikelets during the grain filling phase [8]. Hence, the above-mentioned trend might be the possible reason for yield stability in optimum transplanting dates [25]. In addition, optimal sowing date largely ensures the grain filling, even when the process concomitants with the potential, milder temperatures in autumn [8]. In addition, optimal sowing date largely ensures the

Table 1. Morphological traits under the interactive effect of transplanting dates and rice cultivars.

Transplanting dates x Rice cultivars	Plant height (cm)	Total tillers per hill	Panicle exertion (cm)	Flag leaf length (cm)	Flag leaf width (cm)
1st May					
'Neda'	103.7 ij	21.17 c	3.1 g	29.23 h	1.26 cd
'Hovaze'	137.7 de	17.10 f	4.7 f	39.23 bcd	1.96 a
'Hashemi'	157.7 ab	15.17 gh	6.4 cd	39.50 a-d	1.23 cd
'Domsiah'	158.7 ab	14.83 h	8.3 ab	35.07 fg	1.06 fg
'Tarom'	157.8 ab	16.60 fg	7.5 bc	35.10 fg	1.16 def
'Fajr'	113.5 fg	16.83 f	0.9 hi	34.53 g	1.50 b
21st May					
'Neda'	100.3 j	25.00 a	2.8 g	29.87 h	1.26 cd
'Hovaze'	136.5 e	20.70 cd	4.4 f	39.80 abc	1.97 a
'Hashemi'	156.1 bc	16.20 fgh	7.0 bcd	38.33 cde	1.23 cd
'Domsiah'	158.3 ab	16.83 f	9.1 a	34.47 g	1.02 g
'Tarom'	151.2 c	16.93 f	7.8 bc	36.53 efg	1.18 de
'Fajr'	110.1 gh	23.03 b	1.1 hi	34.40 g	1.50 b
10th June					
'Neda'	106.7 hi	20.00 cde	1.50 h	30.73 h	1.30 c
'Hovaze'	142.7 d	19.33 de	4.78 ef	41.77 a	2.05 a
'Hashemi'	162.7 a	15.20 gh	5.00 ef	41.07 ab	1.30 c
'Domsiah'	160.5 ab	16.07 fgh	4.48 f	36.77 efg	1.12 efg
'Tarom'	157.7 ab	16.33 fgh	5.93 de	37.23 def	1.26 cd
'Fajr'	115.6 f	19.13 e	0.16 i	35.30 fg	1.55 b
LSD (5%)	5.05	1.40	1.25	2.22	0.10

Note: Means in each column followed by the same letter (showing homogenous groups) are not significantly different from each other at 5% level of probability according to the Fisher's LSD (least significant differences) test.

Table 2. Yield and yield components under the interactive effect of transplanting dates of rice cultivars.

Transplanting dates x Rice cultivars	Effective tillers per hill	Panicle length (cm)	Fertile spikelets per panicle	Sterile spikeletsper panicle (%)	1000-grain weight (g)	Grain yield (kg/ha)
			1st May			
'Neda'	18.43 b	23.9 ef	98.83 bcd	18.21 cd	28.83 a	6240 b
'Hovaze'	14.83 efg	22.7 fg	124.4 a	13.17 efg	25.83 bc	3388 l
'Hashemi'	14.17 efg	26.7 cd	93.07 cd	15.05 ef	25.17 bcd	3299 n
'Domsiah'	14.00 fg	28.6 b	98.23 bcd	12.16 fgh	24.50 cde	4346 h
'Tarom'	15.00 def	23.9 ef	93.53 cd	9.906 hi	23.50 d-g	4137 j
'Fajr'	15.67 cd	28.6 b	127.2 a	15.01 ef	22.83 efg	5312 e
			21st May			
'Neda'	21.80 a	23.3 fg	100.9 bc	14.71 ef	29.00 a	6625 a
'Hovaze'	15.93 cd	21.9 g	130.4 a	10.60 ghi	26.50 b	3355 m
'Hashemi'	15.27 de	28.5 b	97.40 bcd	13.48 efg	25.17 bcd	3433 k
'Domsiah'	15.83 cd	28.1 bc	99.77 bc	7.754 ij	24.50 cde	4698 g
'Tarom'	15.67 cd	23.7 ef	97.67 bcd	6.951 j	24.17 c-f	4301 i
'Fajr'	17.83 b	29.6 ab	128.7 a	13.72 ef	22.50 fg	5645 c
			10th June			
'Neda'	18.33 b	24.1 ef	97.77 bcd	22.10 b	25.50 bc	5633 d
'Hovaze'	13.80 fg	22.8 fg	104.0 b	21.87 b	22.50 fg	2675 q
'Hashemi'	13.57 g	26.9 c	80.57 e	19.13 c	22.83 efg	2110 r
'Domsiah'	14.07 efg	30.6 a	89.23 de	15.40 de	23.33 efg	2974 o
'Tarom'	13.67 g	25.26 de	81.07 e	18.01 cd	22.17 g	2947 p
'Fajr'	16.60 c	28.90 b	97.47 bcd	27.42 a	20.17 h	4944 f
LSD (5%)	1.15	1.47	8.76	2.74	1.54	5.15

Note: Means in each column followed by the same letter (showing homogenous groups) are not significantly different from each other at 5% level of probability according to the Fisher's LSD (least significant differences) test.

grain filling, even when the process concomitants with the potential, milder temperatures in autumn [8].

The late transplanting of 10th June only increased the vegetative growth by recording taller plants (162.7 cm) and maximum flag leaf length (41.77 cm). However, late transplanting significantly decreased the yield due to higher number of sterile spikelets (Tables 1 and 2). It has been reported that delayed planting than to the optimum date reduces the yield potential exponentially raised in daily temperature, and plants pave all the growth phases earlier than normal condition [26]. In relation to yield components, the decrease in the number of fertile spikelets in late planted crop mainly resulted from factors such as improper temperature during the maturity and grain filling stages.

The formation of fertile spikelets in the panicle is substantially contingent upon the genetic potentiality of cultivars as well as the photosynthetic products supply during the maturity period. In the late planting, there is an increased risk of sterility for high temperatures at flowering stage. Thus, it seems that in the early and late planted crops, the panicle infertility is plausible, as if the thermal conditions intensify the competition for absorbing photosynthetic products [27]. Rakesh and Sharma [28], were in the opinion that any delay in planting significantly reduces the number of productive tillers per unit area, and ultimately attenuates the paddy yield. Akram *et al*. [29], found less number of grains per panicle in late sowing. Khakwani *et al*. [30] recorded a significant reduction in 1000-grain weight with delay in planting time. Reduction in the 1000-grain weight in the late transplanted crop was primarily due to unfavourable environmental temperatures since the grain formation and grain filling stages. In this regard, Iqbal *et al*. [31] reported that the highest yield was achieved once the rice crop was sown earlier in the season.

All the studied cultivars responded differently for yield components, so that the seedlings that have been transplanted on 21st May showed the more improved yield components. The higher effective tillers and grain yield were found in 'Neda' transplanted on 21st May. This transplanting date equally increased fertile spikelets in 'Hovaze' and 'Fajr' cultivars, respectively. However, seedlings of 'Hovaze' transplanted on 10th June increased the tallness of 'Hashemi'. The highest productive tillers were found in 21st May transplanting which reflects optimum planting time of 'Neda'. The significant differences in terms of growth and yield traits were noted in 'Neda' compared to rest of cultivars across transplanting dates. Most of the cultivars were responsive for recording higher values of yield components in the first two transplanting dates (1st May, 21th May). However, late planted crop due to high temperature caused disorder in grain formation and produced sterile spikelets which reduced the grain yield (Tables 1 and 2). The possible reason for decline in yield components and grain yield as a result of late transplanting (10th June) might be because the temperature has gone increasing in late growing season which ultimately triggered more vegetative growth. The results are fully in alignment with the findings of Reddy and Reddy [32], that delayed planted crops undergo the development stages more rapidly, and each part of a development stage decreases exponentially as the delay in planting process increases. For obtaining a proper number of productive tillers, the relative importance of temperature at the time of panicle emergence for panicle fertility are considered important factors

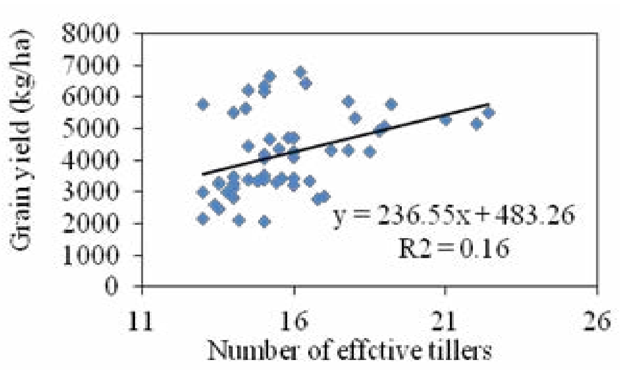

Figure 1. Linear regression between number of effective tillers per hill and grain yield.

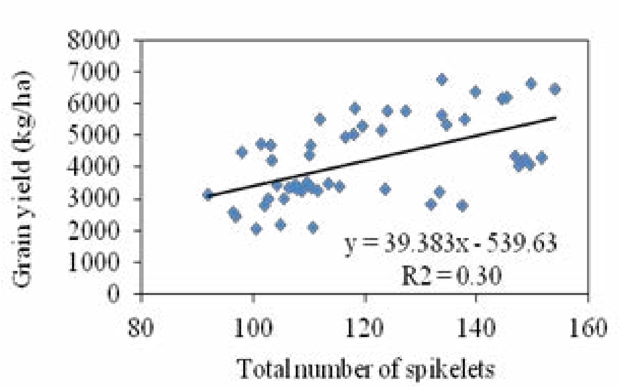

Figure 2. Linear regression between total number of spikelets per panicle and grain yield.

[33]. In this study, the number of productive tillers decreased due to temperature increase in the 10th June planting date as well as genetic potentiality of the cultivar. The heat sensitive cultivar can easily be suppressed by late transplanting due to shortening in

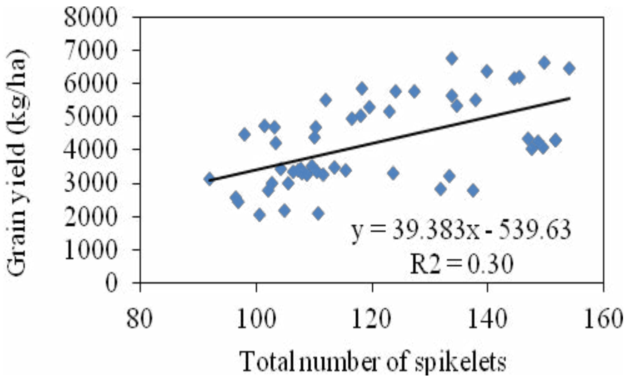

Figure 3. Linear regression between 1000 grain weight and grain yield.

the growth cycle. Thus, in our study less panicle length has been recorded for the cultivars transplanted later on 10th June.

The linear relationship between yield and yield components showed that a unit increase in effective tillers, total number of spikelets and 1000-grain weight correspondingly increased grain yield by 236.6, 39.4 and 72.1 kg/ha, respectively (Figures 1-3). In compliance to our findings, Kariali and Mohapatra [34] were also supported the theory that the grain yield is highly dependent on the number of effective tillers. Grain yield is a function of interplay of various important yield components such as number of fertile spikelets per panicle, productive tillers and 1000-kernel weight [2]. The studies on the relationship between the yield and yield components in rice cultivars for grain yield had shown positive and significant correlation with the number of grains per panicle, the number of filled grains per panicle, and 1000-grain weight.

4. Conclusions

Since the rice cultivars are more sensitive to elevated temperatures, hence, sowing at proper time giving a favourable environmental condition facilitates growth and development and finally ensures yield stability. The crop sown on 1st and 21st May had better growth and yield components which resulted in higher grain yield of 'Neda' as compared to the rest of cultivars. Delay in transplanting inclusively increased the tallness of cultivars; while, the remaining plant characters, such as grain yield were showed decreasing trend in delayed planting beyond 21st May. The correlation study revealed that a unit increase in effective tillers, total number of spikelets and 1000-grain weight correspondingly increased grain yield by 236.6, 39.4 and 72.1 kg/ha, respectively.

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